Comments on November 20 ARB iLUC Workshop

Air Improvement Resource, Inc.

December 4, 2014

Introduction

On November 20 ARB held a third workshop on indirect land use (iLUC) emissions of various biofuels. New land use emission values were presented by the Staff. A summary of the emissions for corn ethanol from the different workshops is shown in Table 1. The emissions of corn ethanol dropped slightly from 21.6 g/MJ to 20 g/MJ.

Table 1. Corn Ethanol iLUC Values (gCO2e/MJ)

Biofuel	Current Regulation	March 2014	September 2014, Approach B	November 2014, Approach B
Corn Ethanol	30.0	23.2	21.6	20.0

Very little new information was presented at this workshop. One decision that ARB made was to use GTAP "Approach B" in estimating land use emissions. Putting to the side numerous other issues related to the iLUC analysis being undertaken by the Staff and stakeholders, the use of "Approach B" is an improvement worthy of support, because it makes the GTAP model ARB is using consistent with the GTAP model developed by Purdue that is described in detail in the January 2013 Applied Science report by Purdue.[1] This approach uses separate elasticities of transformation of Forest-to-Crops and Pasture-to-Crops.

ARB made some changes in the AEZ-EF model, but as of November 30 has not released the AEZ-EF model for review and comment. As a consequence, we cannot comment on this model until it is provided for review. In order to permit effective participation in the rulemaking, ARB should make the model fully available without further delay. Waiting until the 45-day process is not appropriate given the complexity and importance of the issues that the AEZ-EF model is supposed to address.

ARB's price-yield elasticity range stayed the same as the previous workshop. According to ARB, this decision was based on a study by UC Davis. However, the UC Davis study was also not made available, so it is impossible to comment on that decision. ARB should provide public access to the relevant study and supporting materials without further delay. Consequently, our comments on price-yield remain the same as they before, i.e., that ARB should disregard the two lowest price-yield elasticities it is currently using, and use somewhat higher price-yield elasticities, so

[1] Taheripour and Tyner, "Biofuels and Land Use Change: Applying Recent Evidence to Model Estimates", Applied Sciences, 2013, 3, 14-38.

that the average price-yield elasticity is around 0.28 or 0.30, in order to reflect multiple cropping in some countries. Our previous comments on the September 29 workshop that discuss price-yield in more detail are included as Attachment 1 to this document.

This document summarizes our further comments on the workshop and ARB's current land use estimates. It is important to note at the outset that shortly before the workshop, a significant report on using recent land use change data to validate land use change models was released by Iowa State University.[2] The study has important implications for ARB's current land use emission estimates, and thus, important implications for the overall lifecycle emissions of various biofuels as compared to petroleum-derived fuels. In response to a question from a workshop participant, ARB indicated that they had a copy of this study and were reviewing it. We believe that the Staff should address the new study in the ISOR and provide it to the peer reviewers who will be engaged to examine iLUC issues. The ISU report's findings must be used by ARB in conjunction with ARB's GTAP modeling to derive new and updated land use emission estimates for the various biofuels prior to proposing re-adoption of the Low Carbon Fuel Standard (LCFS). Failure to do this would mean that ARB would not be using the latest and best available scientific and economic information to develop its lifecycle emissions for biofuels, which we understand to be required by the governing statute, A.B 32.

Our comments are organized in the following sections:

- Summary of the Babcock/Iqbal study
- Impacts on ARB's iLUC estimates for corn ethanol
- Other Comments

<u>Summary of Babcock/Iqbal Study</u>

The study developed new methods of using existing land cover data to evaluate the extent of land transitions in the time period between 2004-2006 and 2012-2014, the time period of fairly rapid expansion of biofuel in the US. These were compared to both the FAPRI and GTAP model estimates. In short, the paper concludes that the models used by EPA and ARB significantly overestimate pasture and forest conversions to crops in many parts of the world (including the US), because they do not include land "intensification", which includes increased double-cropping, reduced fallow land, and reduced land that is planted but not harvested (in other words, increasing the harvested to planted ratio). The authors purposely did not

[2] "Using Recent Land Use Changes to Validate Land use Change Models", Babcock and Iqbal, Staff Report 14-SR- 109, Center for Agriculture and Rural Development, Iowa State University, www.card.iastate.edu.

consider crop yield improvements, which is another form of intensification and, which if also included, would further reduce iLUC GHG estimates. [3]

The paper first summarizes annual inflation-adjusted price changes in a number of crops from 1965 to 2012, and shows that prices of a number of key crops increased for a number of years from 2004-2012. The paper cites another study by Babcock and others that opines that about one-third of the corn price increase during this time period was due to the biofuel mandate (RFS), other factors such as crop shortfalls and other sources of increased demand account for the rest of the price increase. The reason for showing these price trends was that "the magnitude of these real price increases after such a prolonged and sustained period of flat or falling prices presents a unique opportunity to quantify how world agriculture responds to incentives to produce more." The paper goes on to state that "because indirect land use is a response to higher market prices, model predictions of land use change should be similar whether the higher prices came from increased biofuel production, increased world demand for beef, or from drought that decreased supply. This implies that the pattern of actual land use changes that we have seen since the mid-2000s should be useful to determine the reliability and accuracy of model that have been used to measure indirect land use."

The study then examines changes in "harvested land" between the two periods. The source of this information is the Statistics Division of the Food and Agriculture Organization of the United Nations (FAOSTAT).[4] These data have been widely used to measure the impact of biofuel production on expansion of land used in agriculture and to calibrate the land cover change parameter in the GTAP model used by ARB. [5,6] But the study points out that harvested land is not equal to planted land, and that harvested land will deviate from planted land "when a portion of planted land is not harvested, and when a portion of land is double or triple-cropped." The study examines data from specific countries, and shows that existing land intensification has accounted for 76% of the increase in production in Brazil, and nearly all of the increase in production in India and China.

An alternative measure of land use is developed, which is the change in FAO's arable land plus permanent crops. Figure 8, which plots the changes in this metric from 2004-2006 to 2012-2014 from the report, is shown below. The report states: "The countries in Figure 8 that either had negligible or negative extensive land use changes should be presumed to not have converted pasture or forest to crops in response to biofuel-induced higher prices. Rather, the presumption should be that any predicted change in land used in agriculture came from cropland that did not go

[3] Land "extensification" means conversion of forest and pasture to cropland, whereas "intensification means making existing land (cropland and idle or fallow land) more productive.

[4] http://faostat3.fao.org/home/E

[5] Roberts and Schlenker, "Identifying Supply and Demand Elasticities of Agriculture Commodities: Implications for the US Ethanol Mandate", American Economic Review 103(6): 2265-95

[6] See footnote 1.

out of production." The regions in Figure 8 with negligible or negative extensive land use changes are: Rest of Asia, the European Union, Canada, Russia, Oceania, China, South Africa, India, Central and Caribbean America, Bangladesh, Japan, Rest of East Asia, Other Europe and Remainder of Former Soviet Union, Ukraine, and the US.

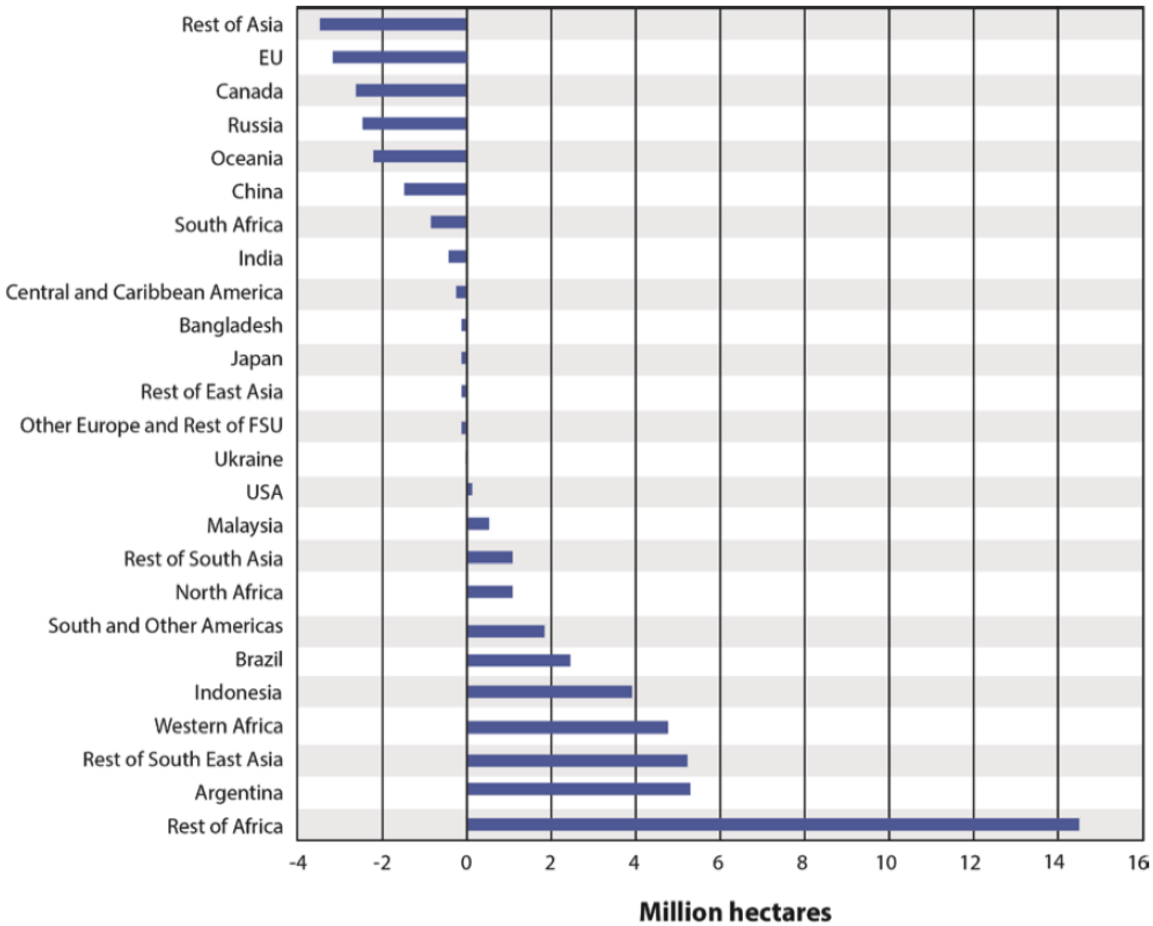

Figure 8. Change in Arable Land Plus Permanent Crops: 2004–2006 to 2010–2012

Figure 8 does show that Western Africa, and the "Rest of Africa", have significant extensive changes in arable land plus permanent crops (see Attachment 2 for countries included in the Africa regions of Figure 8). However, the study indicates that "the extent to which extensive expansion in African countries was caused by high world prices is small for the simple reason that higher world prices were not transmitted to growers in many African countries. Babcock and Iqbal cite a number of studies to support this conclusion.

Impacts of Babcock/Iqbal Study on ARB's ILUC Estimates for Corn Ethanol

As indicated earlier, we do not have ARB's most recent AEZ-EF model so we cannot replicate ARB's 20 g/MJ value for corn ethanol (the 20 g/MJ value is an average based on 30 individual runs of the GTAP model, coupled with the AEZ-EF model). We can, however, use GTAP runs with the ARB GTAP model and AEZ-EF model ARB released as a part of the September 29th workshop to develop an estimate of the impact of Babcock/Iqbal's recommendations.

The primary conclusion from the Babcock/Iqbal study is that there are regions/countries of the world that had negative or negligible extensive land use changes between 2004-2006 and 2012-2014, and these countries and regions should be presumed not to have any forest or pasture conversion to cropland in response to biofuel expansion. The countries and regions in this category were listed earlier. Other countries not on this list can still be presumed to have some extensive land use conversions (i.e., conversion of forest and pasture to crops). Thus, the Babcock/Iqbal study can be used as a filter on the existing GTAP results.

Table 2 shows our GTAP modeling from our comments on the September 29 workshop (found in Table 4 of that report). We show the iLUC for 3 cases:

- Average of ARB inputs
- Purdue best estimate
- AIR recommended inputs

Table 2. ARB Average and Recommended Values (Approach B with Irrigation Constrained) for Corn Ethanol

Case	Ydel	PAEL	ETA	AIR Estimated LUC gCO2e/MJ
Average of ARB Inputs	0.19	0.3/0.15	Baseline	17.22
Purdue Best Estimate	0.25	0.4/0.2	Baseline	14.23
AIR Recommended*	0.28	0.4/0.2	Baseline	13.23

The case with the "Average of ARB Inputs" is 17.22 gCO2e/MJ. This is less than ARB obtained with its average of the 30 scenario runs (21.6 gCO2e/MJ), but nonetheless, we can use this case to estimate the impacts of applying the country/region filter from the Babcock/Iqbal analysis.

Table 3 shows emissions from land transitions for the ARB average case. As shown in the table, Forest-to Crop transitions comprise 60% of emissions, and Pasture-to-Crop transitions comprise 21% of emissions.

Table 3. Land Transition Emissions for the ARB Average Case	
Land Transition	ARB Average, Megagrams CO2e
Forest-to-Crop	305,579,609
Pasture-to-Crop	109,196,645
Cropland-pasture to Crop	114,309,541
Crop-to-Forest	0
Crop-to-Pasture	0
Crop-to-Cropland pasture	0
Pasture-to-Forest	-20,801,279
Forest-to-Pasture	124,717
Total	508,409,234

The breakdown of Forest-to-Crop and Pasture-to-Crop emissions by GTAP region for the ARB average case are shown in Table 4. We have not shown areas with less than 1% contribution. We also have bolded the regions that Babcock/Iqbal indicate would not have Forest-to-Cropland or Pasture-to-Cropland transitions. (Our mapping of the Babcock/Iqbal regions which come from FAOSTAT, to the GTAP regions is shown in Attachment 3.)

We have shaded the sub-Sahara region[7] for several reasons – (1) GTAP predicts it is the largest contributor to emissions for the corn-ethanol expansion, (2) the Babcock/Iqbal analysis shows that the country of South Africa, part of sub-Sahara Africa, should not have forest to crop and pasture to crop transitions, and (3) we are not sure how to separate South Africa from the sub-Sahara region in GTAP, and (4) the Babcock/Iqbal report also indicates that the expansion of cropland from forest and pasture in many African countries is not price-induced.

Thus, on one hand, Babcock/Iqbal are making the case that the extensive land changes in Africa are not price driven, and therefore, not related to biofuel expansion, and so in one case the sub-Saharan region can be omitted from the corn ethanol emissions analysis. On the other hand, if these countries are included in the emissions analysis because they do have extensive land use changes, the emissions will be over-predicted because of our current inability to remove South Africa from the sub-Saharan region. Nonetheless, we will estimate iLUC emissions for these two cases – one without sub-Sahara Africa, and one with.

[7] The sub-Sahara region in GTAP includes Botswana, South Africa, Rest of South African Customs Union, Malawi, Mozambique, Tanzania, Zambia, Zimbabwe, Rest of South African Development Community, Madagascar, Uganda, and rest of sub-Saharan Africa.

Table 4. Regional Forest-Crop Plus Pasture-Crop Transition Emissions for ARB Average		
Region	Megagrams	Percent of Total Forest-to-Crop and Pasture-to-Crop Emissions
USA	**43,316,687**	**10%**
EU27	**15,681,094**	**4%**
Brazil	56,258,521	14%
Canada	**14,911,705**	**4%**
Japan	**3,745,849**	**1%**
China + Hong Kong	**16,121,420**	**4%**
India	**7,732,753**	**2%**
South America (w/o Brazil)	14,930,904	4%
Rest of Southeast Asia	13,248,332	3%
Rest of South Asia	5,810,952	1%
Other CEE_CIS	**7,867,793**	**2%**
Mideast North Africa	**2,629,014**	**1%**
Sub-Sahara Africa	**204,901,423**	**49%**
Oceania	2,628,749	1%

The results of our analysis of iLUC emissions for the ARB average case, with and without sub-Sahara Africa being included with the other areas without Forest-to-Crop and Pasture-to-Crop transitions, is shown in Table 5. Application of the Babcock/Iqbal analysis reduces iLUC emissions between 21% and 65%, depending on the treatment of emissions in sub-Sahara Africa. The range for corn ethanol for the Purdue Best Estimate (input elasticities) is between 5 and 11 g CO2e/MJ, far lower than ARB's current 20 g CO2e/MJ estimate.

Table 5. Impacts of the Babcock/Iqbal Filter on GTAP Results (g/CO2e/MJ)		
Scenario	ARB Average	Purdue Best Estimate
No Filter (from Table 2)	17.2	14.2
Filter without sub-Sahara impacts	13.3 (-21%)	10.9 (-22%)
Filter with sub-Sahara impacts	6.1 (-64%)	5.0 (-65%)

ARB should revise its iLUC emissions for various biofuels to account for the Babcock/Iqbal analysis. The reasons why emissions are lower with application of their analysis are not new – they are related to multiple cropping in certain regions, the use of idle or fallow land, and the improvement in harvested versus planted land, which are all related to higher prices for commodities. None of these items is currently included in the GTAP model that ARB is using.

Other Comments on the Workshop

Price-Yield Elasticity

As indicated earlier, ARB has stated its intent to use its current price elasticity range, with an average elasticity of 0.19. The Purdue estimate is 0.25, and it does not account for double-cropping or other intensification measures used by the agriculture industry. We have been recommending a price-yield elasticity range of 0.2-0.5, with an average of 0.28, slightly higher than the Purdue best estimate, to account for some multiple cropping. After reviewing the Babcock/Iqbal analysis, we think the best way to account for multiple cropping in the short term is by applying the Babcock/Iqbal filter. Therefore, if ARB were to utilize the Babcock/Iqbal filter on its results, the price-yield range should be modified to have an average of 0.25 at the Purdue best estimate. We do not support ARB's current range, because the lower end of the range is based on very short-term price-yield studies, and GTAP is a medium to long-term model.

Conservation Reserve Program Land (CRP) in the US

We have submitted comments showing that a large amount of ex-CRP land appears to have come into production in the US in the last 7 years (see page 5 in Attachment 3).[8] The GTAP model is capable of accessing this land, but in the ARB version of the model the option to access this land within GTAP has been turned off. It is very straightforward to turn this option on. The Babcock/Iqbal study also identifies ex-CRP land as a factor in confirming that there has been no forest or pasture transformations to cropland in the US (see pages 29-30 of the study). Implementation of the CRP land option in GTAP reduces emissions for the ARB average case from 17.22 gCO2/MJ to 16.35 g CO2e/MJ.

If ARB decides to use the Babcock/Iqbal study as a filter to determine regions with forest to crop and pasture to crop transitions, then there is no need to modify GTAP to access CRP lands. However, if ARB decides not to use the Babcock/Iqbal study as a filter, then the GTAP modeling used by ARB should allow the model to access CRP land, because that is what has already happened.

Cropland/Pasture Elasticity (PAEL)

In its modeling scenarios, ARB is only examining cropland/pasture elasticity values of 0.2/0.1 (US/Brazil) and 0.4/0.2. The 0.4/0.2 levels are Purdue's default or best

---

[8] "Comments on ARB's March 11 Workshop on The Low Carbon Fuel Standard, Air Improvement Resource Inc., April 6, 2014 (provided in Attachment 4).

estimate. So, ARB is examining the Purdue best estimate and one-half that level (lower levels increase the iLUC emissions).

We indicated in our comments on the September 29 workshop and also in the November 20 workshop, that ARB should estimate emissions for three PAEL levels for the US and Brazil. Two of the levels are the same as the ARB's current levels, the third one is 0.6/0.3. ARB had previously planned on using the 0.6/0.3 values. In response to our question as to why PAEL levels of 0.6/0.3 were dropped from the analysis, ARB indicated that there was a problem with the run, and promised further information on this. To date, we have not seen that information.

We therefore ran the 0.6/0.3 case using the ARB average price yield elasticity of 0.19 and the baseline ETA value. We encountered no problems with the run, and obtained emissions of 15.55 gCO2e/MJ (as compared to 17.22 g/MJ for the ARB average case using PAEL levels of 0.3/0.15). We therefore recommend that ARB re-instate the 0.6/0.3 PAEL case in its scenario runs, or explain in detail what its concerns are with this case.

Longer-Term Items

ARB appears to have only 4 items on its agenda for longer-term study (see page 29 of the November 20 workshop handout):

- Address forestry issue in the model
- Account for fertilizer, livestock, and paddy rice emissions
- Include analysis for cellulosic feedstocks
- Develop and validate dynamic GTAP model

Notably absent from this list are all the items which Babcock/Iqbal identify as primary drivers of less Forest-to-Crop and Pasture-to-Crop transitions (and thus the overall iLUC emissions of biofuels) in many regions of the world, such as (1) multiple cropping (double- and even triple-cropping), (2) use of temporary fallow/idle land, (3) less land that is planted and not harvested, and (4) the use of CRP land in the US. In addition, stakeholders reviewing ARB's iLUC estimates have made numerous comments about multiple cropping, the use of CRP, idle land, etc. Many of these items were identified 4-5 years ago by various stakeholders. None should be deferred from action in the current rulemaking, if ARB's intent is to use the best available scientific information and analysis, as A.B. 32 requires.

The amount of temporary or fallow land can actually be computed from the GTAP land cover. In GTAP there are two layers of information on cropland; land cover and harvested area. Any land which has been cultivated in the past is included in the cropland category under the land cover header. This category of land includes all types of cropland (cultivated and idled land such as planted but not harvested, cropland-pasture, CRP, or fallow). The cropland area is generally not divided into different types (except partially for the US and Brazil). The second layer is harvested area. Harvested area refers to the cropland that is harvested in the base year (i.e. 2004).

The version of GTAP used by CARB has cropland-pasture for the US and Brazil and CRP area for the United States added to the harvested land layer. The model does not allow conversion of CRP land to crop production (the model keeps it under the conservation program). However, cropland-pasture which is used for grassing tasks can be converted back to crop production. Cropland-pasture in the other regions of the world and fallow land (either deliberately not planted or having a harvest failure) are not included in the harvested land layer. The model currently has no capability of accessing this land for increased crop production even though it is probably the most likely land to respond to higher crop demand and is land that could be brought into production without any land use change.

In some areas of the world two or more crops can be harvested from the same land in a given year. In these areas, the harvested land may be greater than the cropland area. While some regions may have both fallow land and double-cropped land from this data we can only show the net fallow land (i.e., net cropland not in crops) and the net double-cropped land. A summary of these lands by model region is shown in Table 6.[9]

[9] Darlington, Kahlbaum, O'Connor, and Mueller, "Land Use Change Greenhouse Gas Emissions of European Biofuel Policies Utilizing the Global Trade Analysis Project Model, August 30,2013.

Table 6. GTAP Land Summary (Ha)				
GTAP Region	Cropland	Harvested Area	Net Cropland Not in Crops	Net Double-Cropped
USA	175,807,007	167,059,000	8,748,007	
EU27	124,830,687	115,729,000	9,101,687	
BRAZIL	60,724,257	86,403,000		-25,678,743
CAN	39,573,515	33,514,000	6,059,515	
JAPAN	3,680,435	4,185,000		-504,565
CHIHKG	140,644,611	160,840,000		-20,195,389
INDIA	171,418,998	186,799,000		-15,380,002
C_C_Amer	56,671,461	26,687,000	29,984,461	
S_o_Amer	58,603,527	56,585,000	2,018,527	
E_Asia	5,190,174	4,852,000	338,174	
Mala_Indo	71,571,068	35,999,000	35,572,068	
R_SE_Asia	53,207,433	60,163,000		-6,955,567
R_S_Asia	46,956,517	43,712,000	3,244,517	
Russia	124,542,334	81,229,000	43,313,334	
Oth_CEE_CIS	111,522,274	94,998,000	16,524,274	
Oth_Europe	933,565	1,160,000		-226,435
MEAS_NAfr	53,633,308	49,933,000	3,700,308	
S_S_AFR	211,016,073	175,792,000	35,224,073	
Oceania	33957545	42,181,000		-8,223,455
Total	1,544,484,789	1,427,818,000	193,828,945	-77,164,156

In addition, ARB currently assumes that cropland-pasture that is converted to cropland experiences 50% of the emissions of conversion of permanent pasture. This is strictly an assumption. Purdue currently estimates conversion of cropland-pasture has the same emissions as crop-to-crop conversions. This should also be a focus of future research.

Attachment 1

Comments on ARB's September 29th Workshop
On Land Use Change Emissions
Air Improvement Resource, Inc.
October 17, 2014

Introduction

On September 29, 2014 ARB held a workshop on land use change emissions. ARB presented new information on its analysis of LUC emissions for corn ethanol, soybean biodiesel, canola biodiesel, cane ethanol and sorghum ethanol.

We have reviewed the information CARB presented, and also have obtained the new GTAP model and performed some additional modeling runs. Our comments are presented in the following sections:

- Irrigated/Rain-Fed Cropland Category
- Land Supply Structure
- ETL11, ETL12, ETL4 and ETL5
- ARB's 30-Scenario Average
- Yield-Price Elasticity
- Cropland-pasture Elasticity
- Corn Ethanol LUC Impacts of our Recommendations

Irrigated/Rain-fed Cropland Category

Earlier versions of the GTAP model used an average of irrigated and rain-fed cropland. The expansion of cropland in the model did not differentiate between irrigated or rain-fed areas. Irrigated cropland typically has a higher yield compared to rained cropland in a given Region and AEZ. If cropland expansion occurs on irrigated land, higher yields translate into smaller land requirements. But, availability of water for irrigation may be the constraint that limits expansion into irrigated land.

The new version of GTAP developed by Purdue for ARB includes an option to differentiate between irrigated and rainfed cropland. The availability of irrigated land for cropland expansion then can be constrained in certain regions and AEZs, if there is sufficient evidence to constrain expansion of irrigated lands.

ARB used analyses and data from the World Resources Institute (WRI) to determine which regions and AEZs within these regions to constrain expansion into irrigated land. Figure 1 shows the Regions and AEZs where irrigated land is constrained for the ARB LUC analyses. These regions and AEZs were determined from the WRI reports. [1011]

---

[10] *Aqueduct Global Maps 2.1: Constructing Decision-Relevant Global Water Risk Indictors*, WRI, April 2014.

Figure 1

GTAP: Water Constrained Regions/AEZs

AEZ →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Region ↓																		
1 USA							1	1	1				1	1				
2 EU27									1									
3 BRAZIL																		
4 CAN							1	1										
5 JAPAN									1			1						
6 CHIHKG							1	1	1	1			1					
7 INDIA	1	1	1				1	1	1	1					1	1		
8 C_C_Amer	1	1					1	1	1	1	1							
9 S_o_Amer	1	1					1	1	1									
10 E_Asia											1							
11 Mala_Indo				1	1													
12 R_SE_Asia																		
13 R_S_Asia	1		1				1	1	1	1			1					
14 Russia																		
15 Oth_CEE_CIS							1	1					1	1				
16 Oth_Europe																		
17 MEAS_NAfr			1	1			1	1	1	1								
18 S_S_AFR								1										
19 Oceania	1							1	1	1	1							

1 indicates water constrained

We reviewed the WRI reports, but were unable to determine how ARB used the information in these reports to identify the regions and AEZs that should have irrigated land constrained. To our knowledge, there is no technical documentation of how this was done that can be reviewed.

ARB presented little information at the workshop to evaluate the size of this impact on land use emissions. To evaluate the impact of constraining expansion on irrigated land, AIR ran GTAP with and without the irrigation constraint for corn ethanol, using Purdue and ARB's average elasticity inputs. The results are shown in Table 1.

Table 1. LUC Impact of Constraining Crop Expansion on Irrigated Land in Some Areas: Corn Ethanol

Scenario	Ydel	PAEL	ETA	Irrigation Constrained?	LUC (gCO2e/MJ)
Purdue Best Estimates	0.25	0.4/0.2	Baseline	No	14.23
				Yes	13.32
ARB Average	0.19	0.3/0.15	Baseline	No	17.22
				Yes	16.09

[11] *A Weighted Aggregation of Spatially Distinct Hyrdrological Indicators*, WRI, December 2013.

For corn ethanol, constraining expansion on irrigated land adds 0.89 g/MJ for the Purdue default case, and by 1.13 g/MJ for the ARB average. This is not a large effect, but we think it is essential that ARB document how the WRI data was used to develop areas on which cropland cannot be expanded, before including this effect for the various biofuel feedstocks.

Land Supply Structure

The land supply structure in GTAP was revised in 2013 to include four nesting structures instead of two.[12] Prior to 2013, one nest included the substitution of different types of land – forestland, cropland, and pastureland – and a second nest under cropland that included different types of crops. One elasticity – ETL1 – governed the substitution between forestland, cropland, and pastureland, and a second elasticity – ETL2 – governed the substitution between crop types. A significant concern of ARB's Expert Working Group (EWG) was that forestland, cropland, and pastureland were all in the same nest with one elasticity, which meant that forestland is as readily converted to cropland (and vice versa) as pastureland. Clearly this is not the case – the economics of converting forest to crops must be much different than converting pasture to crops.

In 2013, the land supply structure was modified by Purdue, such that the first nest includes only forestland and a second category called cropland+pasture. The second nest under cropland+pasture was divided into cropland and pastureland. The third nest under cropland was divided into irrigated and rain-fed. Finally, both irrigated and rain-fed cropland was divided into different crops. The following new elasticities were defined:

- ETL11: substitution at the first level between forest and cropland+pasture
- ETL12: substitution at the second level between cropland and pasture
- ETL2: substitution between irrigated and rain-fed
- ETL4: substitution between crops under irrigated land
- ETL5: substitution between crops under rain-fed land

The new land supply structure allows the use of more disaggregated elasticities of transformation between land types.

ARB modeled two approaches in estimating land use emissions – Approach A which assumes ETL11=ETL12, and Approach B which provides separate estimates for ETL11 and ETL12. Approach A is essentially the GTAP model prior to the land supply improvements (i.e., only 1 elasticity which governs conversion of forest, crop, and pasture), while Approach B is the GTAP model with the improvements (expanded nesting supply structure). Elasticity values for Approaches A and B are shown in Attachment 1. In both approaches, the ETL2 values are identical; it is only the ETL11 and ETL12 values that are different between the approaches.

12 Taheripour and Tyner, "Biofuels and Land Use Change: Applying Recent Evidence to Model Estimates", Applied Sciences, 2013, 3, 14-38.

ARB did not implement Approach B in its materials presented at the March 11, 2014 workshop, in spite of the fact that GTAP was updated for land supply structure over a year earlier in January 2013. One of Growth Energy's primary comments on the materials ARB supplied at the March 11 workshop was that ARB should utilize a GTAP model with the updated land supply structure with different elasticities of conversion for forest and pasture. (i.e., Approach B). We further think that Approach A is outdated and does not at all reflect reality, and that ARB should drop Approach A in estimating land use changes due to biofuel expansion. Approach A is *not* an equally technically appropriate alternative to Approach B. Purdue no longer utilizes Approach A – it is simply now an approach that tries to mimic the old GTAP model prior to the significant improvements made in early 2013.

ETL11, ETL12, ET4, ETL5

ARB's ETL11, ETL12, ETL4, and ETL5 values for Approach B were presented in Slide 24 of the September 29 presentation. We support the use of these values.

ARB's 30-Scenario Average LUC Emissions

In the March 11 workshop, ARB modeled 1440 separate scenarios for each biofuel, and averaged the results of these scenarios to estimate LUC for each biofuels. In the September 29 workshop, Staff had reduced this to 30 separate GTAP runs, varying 3 separate input elasticities: the yield-price elasticity (YPE, or Ydel), the cropland-pasture elasticity (PAEL) for the US and Brazil, and the elasticity of crop yields with respect to area expansion (ETA). There are five values for Ydel, 2 for PAEL, and 3 for ETA (5*3*2 = 30).

Growth Energy commented previously that the number of runs should be reduced (and they have), and further support doing GTAP runs at varying elasticities, since these can affect the results. However, we believe that ARB has selected the wrong range of values to use for two of the input elasticities.

It is worth noting that Purdue has best estimates for each of these inputs. The ARB input values and Purdue best estimates are shown in Table 2.

Table 2. ARB Input Elasticities Compared to Purdue Best Estimates				
Parameter	Description	ARB Values	ARB Average Value	Purdue Best Estimate
YPE	Yield-Price Elasticity	0.05, 0.125, 0.175, 0.25, 0.35	0.19	0.25
PAEL	Cropland-pasture elasticity*	0.2/0.1, 0.4/0.2	0.3/0.15	0.4/0.2
ETA**	Elasticity of crop yields with respect to area expansion	Baseline, 80% of baseline, 120% of baseline	Baseline	Baseline

*The first value is for the US, the second for Brazil
** ETA varies by region. The baseline values used by ARB are the same as used by Purdue

For YPE, the ARB range is from 0.05 to 0.35, with an average value of 0.19. The range in the March 11 workshop was from 0.05 to 0.30, so ARB has increased the upper end of this range by 0.05. The average value is lower than the Purdue best estimate of 0.25, and lower values yield to higher land use emissions. For PAEL, ARB selected the ARB best estimate and an estimate one-half of that. The average of the two ETA values for Brazil and the US is lower than the Purdue best estimate. Again, lower values lead to higher land use emissions. Finally for ETA, ARB selected the Purdue best estimate as the central value, and values higher and low than the best estimate. The average of the three is at the Purdue best estimate.

For PAEL, ARB seems to have followed the methodology of selecting values higher than and lower than the Purdue best estimate. This approach makes sense to us. However, for YPE and ETA, ARB selected values rather arbitrarily that yield an average value that is significantly different than the Purdue best estimate. ARB has not presented reasons or a rationale why it did this, so it appears they did this for the sole purpose of increasing the land use emissions of crop-based biofuels.

We present the impacts of this arbitrary decision making process later in these comments.

<u>Yield-Price Elasticity (YPE, also Ydel)</u>

In our comments on the previous workshop, we indicated that GTAP is a medium term model, and that YPE values developed over the very short term were not appropriate. The values below 0.15 referenced by ARB were short-term values, therefore; ARB should not be using values below 0.15 (i.e., 0.05 and 0.125), as they are not consistent with GTAP's general timeframe.

In addition, in our previous comments we presented information showing that Purdue's best estimate value of 0.25 does not include double-cropping, conversion of fallow land to cropland in the US, Canada and the EU27 regions, and conversion of Conservation Reserve Program (CRP) land in the US. We presented much evidence on the conversion of fallow land and CRP land in those comments. CRP land is in the GTAP land supplies and could be utilized directly. We pointed out that both double-cropping and fallow land conversion could be simulated with higher Ydel values (i.e., values above 0.25).

As indicated in the previous section, ARB used two values below 0.15 – 0.05 and 0.15. We believe these should be dropped from the Ydel analysis since they are not consistent with GTAP. Second, we believe ARB should expand the upper limit of Ydel to 0.50. The values we are recommending are 0.15, 0.2, 0.25 (Purdue best estimate), 0.3, and 0.5. The average of these values is 0.28, which is only 0.03 above the Purdue best estimate, and a reasonable conservative average to reflect a small amount of double-cropping and/or fallow land conversion.

Cropland-pasture Elasticity (PAEL)

ARB used the Purdue best estimate (0.4/0.2) and one-half of the best estimate (0.2/0.1). There is no information given on why ARB used one-half of the Purdue best estimate, without also using something above the Purdue best estimate, for example, 0.6/0.3. Using a sensitivity analysis on only the "low" side of the Purdue best estimate skews the land use values higher. We recommend running three PAEL values, where one is the Purdue best estimate and the other two are higher and lower than the Purdue best estimate.

Corn Ethanol LUC Impacts of our Recommendations for Elasticity Inputs

We did not run all of CARB's 30 cases to establish a baseline, but instead, we ran the average of the elasticity inputs, and the high and low. Results are shown in Table 3, compared to ARB's results of the 30 runs. As shown in Table 3, AIR's values are lower than ARB's values. The reasons for this are not clear. Our program files have been provided to the staff for these cases for review. For now, we have also constrained expansion on irrigated land, even though we have not had a chance to review the method ARB used to incorporate data and information from the two WRI reports.

Table 3. ARB Average, Low and High LUC Emissions for Corn Ethanol (Approach B with Irrigation Constrained)

Case	Ydel (Yield-price elasticity)	PAEL	ETA	AIR Estimated LUC gCO2e/MJ	ARB Estimated LUC gCO2e/MJ
Average of ARB Inputs	0.19	0.3/0.15	Baseline	17.22	21.6
ARB "High"	0.05	0.2/0.1	80% of Baseline	34.49	37.0
ARB "Low"	0.35	0.4/0.2	120% of Baseline	9.68	11.5

Basically, we are recommending that ARB use the Purdue best estimates for elasticity inputs, except for Ydel, which we believe should average about 0.28 or so to reflect some double-cropping which typically takes place in Brazil and to a lesser extent in the US and other areas, and also conversion of some fallow land in the US, Canada, and the EU27, at a minimum. We have estimated emissions by utilizing average input parameters, instead of making 45 runs; but acknowledge that it would be more precise to perform the 45 runs and determine average emissions, since some of the effects are likely not to be linear.[13] Results are shown in Table 4.

Table 4. ARB Average and Recommended Values (Approach B with Irrigation Constrained) for Corn Ethanol

Case	Ydel	PAEL	ETA	AIR Estimated LUC gCO2e/MJ
Average of ARB Inputs	0.19	0.3/0.15	Baseline	17.22
Purdue Best Estimate	0.25	0.4/0.2	Baseline	14.23
AIR Recommended*	0.28	0.4/0.2	Baseline	13.23

* We recommend performing the 45 runs and determining the average emissions, which may differ from 13.23 g/MJ.

The LUC with the Purdue best estimate inputs is 14.23 gCO2e/MJ. Our recommendation results in LUC emissions of 13.23 gCO2e/MJ, based on these inputs.

[13] 45 = 5 Ydel values (0.15, 0.2, 0.25, 0.3, 0.5), 3 PAEL values (0.2/0.1, 0.4/0.2, 0.6/0.3), and 3 ETA values (baseline, 80%, 120%).

Attachment 1

Approach A: ETL11 = ETL12

GTAP Region	ETL11	ETL12	ETL2	GTAP Region	ETL11	ETL12	ETL2
USA	-0.02	-0.02	-0.75	R_SE_Asia	-0.3	-0.3	-0.50
EU27	-0.02	-0.02	-0.75	R_S_Asia	-0.1	-0.1	-0.75
BRAZIL	-0.2	-0.2	-0.75	Russia	-0.02	-0.02	-0.75
CANADA	-0.02	-0.02	-0.25	Oth_CEE_CIS	-0.02	-0.02	-0.75
JAPAN	-0.2	-0.2	-0.50	Oth_Europe	-0.02	-0.02	-0.25
CHIHK	-0.2	-0.2	-0.25	MEAS_NAfr	-0.02	-0.02	-0.25
INDIA	-0.1	-0.1	-0.25	S_S_AFR	-0.3	-0.3	-0.25
C_C_Amer	-0.02	-0.02	-0.25	Oceania	-0.02	-0.02	-0.25
S_o_Amer	-0.1	-0.1	-0.50				
E_Asia	-0.2	-0.2	-0.50				
Mala_Indo	-0.3	-0.3	-0.25				

Approach B: Separate ETL11 and ETL12

GTAP Region	ETL11	ETL12	ETL2	GTAP Region	ETL11	ETL12	ETL2
USA	-0.0182	-0.0218	-0.75	R_SE_Asia	-0.2727	-0.3273	-0.50
EU27	-0.0182	-0.0218	-0.75	R_S_Asia	-0.0909	-0.1091	-0.75
BRAZIL	-0.1905	-0.2095	-0.75	Russia	-0.0182	-0.0218	-0.75
CANADA	-0.0182	-0.0218	-0.25	Oth_CEE_CIS	-0.0182	-0.0218	-0.75
JAPAN	-0.1818	-0.2182	-0.50	Oth_Europe	-0.0182	-0.0218	-0.25
CHIHK	-0.1818	-0.2182	-0.25	MEAS_NAfr	-0.0182	-0.0218	-0.25
INDIA	-0.0909	-0.1091	-0.25	S_S_AFR	-0.2727	-0.3273	-0.25
C_C_Amer	-0.0182	-0.0218	-0.25	Oceania	-0.0182	-0.0218	-0.25
S_o_Amer	-0.0909	-0.1091	-0.50				
E_Asia	-0.1818	-0.2182	-0.50				
Mala_Indo	-0.2727	-0.3273	-0.25				

Attachment 2
Countries in Africa Regions

Region	Country
Rest of Africa	Angola
Rest of Africa	Botswana
Rest of Africa	Burundi
Rest of Africa	Cameroon
Rest of Africa	Central African Republic
Rest of Africa	Chad
Rest of Africa	Comoros
Rest of Africa	Congo
Rest of Africa	Democratic Republic of the Congo
Rest of Africa	Djibouti
Rest of Africa	Equatorial Guinea
Rest of Africa	Eritrea
Rest of Africa	Ethiopia
Rest of Africa	Gabon
Rest of Africa	Kenya
Rest of Africa	Lesotho
Rest of Africa	Madagascar
Rest of Africa	Malawi
Rest of Africa	Mauritius
Rest of Africa	Mayotte
Rest of Africa	Mozambique
Rest of Africa	Namibia
Rest of Africa	Réunion
Rest of Africa	Rwanda
Rest of Africa	Sao Tome and Principe
Rest of Africa	Seychelles
Rest of Africa	Somalia
Rest of Africa	Swaziland
Rest of Africa	Uganda
Rest of Africa	United Republic of Tanzania
Rest of Africa	Zambia
Rest of Africa	Zimbabwe
North Africa	Algeria
North Africa	Egypt
North Africa	Libya
North Africa	Morocco
North Africa	Sudan (former)
North Africa	Tunisia
North Africa	Western Sahara

Western Africa	Benin
Western Africa	Burkina Faso
Western Africa	Cabo Verde
Western Africa	Côte d'Ivoire
Western Africa	Gambia
Western Africa	Ghana
Western Africa	Guinea
Western Africa	Guinea-Bissau
Western Africa	Liberia
Western Africa	Mali
Western Africa	Mauritania
Western Africa	Niger
Western Africa	Nigeria
Western Africa	Saint Helena, Ascension and Tristan da Cunha
Western Africa	Senegal
Western Africa	Sierra Leone
Western Africa	Togo
South Africa	South Africa

Attachment 3

Table 3-1 below shows our mapping of the Babcock/Iqbal regions into the GTAP regions. There is not a 1 to 1 relationship between some of these regions, for example, therefor for the Babcock/Iqbal country of Bangladesh, there is no separate GTAP region, but it is part of the GTAP region Rest of South Asia, or 13 R_S_Asia.

Table 3-1. Preliminary Mapping of Babcock/Iqbal to GTAP

Babcock/Iqbal	GTAP
Rest of Asia	E_Asia
EU	EU27
Canada	CAN
Russia	Russia
Oceania	Oceania
China	CHIHKG
South Africa	S_S_Afr
India	INDIA
Central and Caribbean America	C_C_Amer
Bangladesh	R_S_Asia
Japan	JAPAN
Rest of East Asia	E_Asia
Other Europe and Rest of FSU	Oth_CEE_CIS
Ukraine	Oth_Europe
USA	USA
Malaysia	Mala_Indo
Rest of South Asia	R_S_Asia
North Africa	MEAS_Nafr
South and Other Americas	S_o_Amer
Brazil	BRAZIL
Indonesia	Mala_Indo
Western Africa	MEAS_Nafr
Rest of South East Asia	R_SE_Asia
Argentina	S_o_Amer
Rest of Africa	MEAS_Nafr

We evaluated all of the countries between the Babcock/Iqbal grouping and the GTAP regions. All matched except the countries shown in Table 3-2. We also show the GTAP regions they were assigned to in our analysis.

Table 3-2. Mismatches between Babcock/Iqbal and GTAP				
Babcock/Iqbal Region	Babcock/Iqbal Country	GTAP Region	GTAP Region/Subregion Name	Mismatch Reason
Bangladesh	Bangladesh	13 R_S_Asia	Rest of South Asia	Not a separate GTAP region
Indonesia	Indonesia	11 Mala_Indo	Malaysia and Indonesia	Not a separate GTAP region
Malaysia	Malaysia	11 Mala_Indo	Malaysia and Indonesia	Not a separate GTAP region
North Africa	Sudan (former)	MEAS_Nafr	Rest of Middle East	Different region grouping
North Africa	Western Sahara	MEAS_Nafr	Rest of Middle East	No equivalent
Rest of Asia	Cyprus	02 EU27	European Union 27	Different region grouping
Rest of Asia	Bahrain	17 MEAS_NAfr	Rest of Middle East	Different region grouping
Rest of Asia	Iraq	17 MEAS_NAfr	Rest of Middle East	Different region grouping
Rest of Asia	Israel	17 MEAS_NAfr	Rest of Middle East	Different region grouping
Rest of Asia	Jordan	17 MEAS_NAfr	Rest of Middle East	Different region grouping
Rest of Asia	Kuwait	17 MEAS_NAfr	Rest of Middle East	Different region grouping
Rest of Asia	Lebanon	17 MEAS_NAfr	Rest of Middle East	Different region grouping
Rest of Asia	Oman	17 MEAS_NAfr	Rest of Middle East	Different region grouping
Rest of Asia	Qatar	17 MEAS_NAfr	Rest of Middle East	Different region grouping
Rest of Asia	Saudi Arabia	17 MEAS_NAfr	Rest of Middle East	Different region grouping
Rest of Asia	Syrian Arab Republic	17 MEAS_NAfr	Rest of Middle East	Different region grouping
Rest of Asia	United Arab Emirates	17 MEAS_NAfr	Rest of Middle East	Different

				region grouping
Rest of Asia	Yemen	17 MEAS_NAfr	Rest of Middle East	Different region grouping
Rest of Asia	Occupied Palestinian Territory			No equivalent
Rest of South Asia	Iran (Islamic Republic of)	17 MEAS_NAfr	Rest of Middle East	Different region grouping
South Africa	South Africa	18 S_S_AFR	Sub Saharan Africa	Not a separate GTAP region

Attachment 4

Comments on ARB's March 11 Workshop on The Low Carbon Fuel Standard

Air Improvement Resource, Inc.
April 6, 2014

These comments are primarily on the workshop presentations provided by CARB, and some of the documentation provided by CARB on the AEZ-EF model shortly after the workshop. The following comments focus on Land Use Change and Facility Registration components of the LCFS.

Land use Change Emissions

There are two models used to estimate the land use change emissions – the Agri Economic Zone Emission Factor (AEZ-EF) model, and the Global Trade Analysis Project (GTAP). GTAP is a general equilibrium model used to determine land transitions (like pasture to cropland and forest to cropland) in similar agro-economic zones in various regions of the world. The AEZ-EF model is used in conjunction with the GTAP to determine emissions released by the land-use transitions.

We discuss the GTAP model first, followed by the AEZ-EF Model. We then use the ARB-GTAP model and a much more appropriate Purdue GTAP model to estimate the impacts of our recommendations of changes on land use change (LUC) emissions for corn ethanol.

<u>Global Trade Analysis Project (GTAP)</u>

GTAP contains global land pools of cropland, forest, pasture, Conservation Resource Program (CRP) land (in the US), and cropland pasture (in the US and Brazil). The base year for the current model is calendar year 2004. In modeling biofuel increases, the model is "shocked" with the biofuel increase (corn ethanol, for example), and since this requires a significant increase in corn production, the model converts some other cropland to corn production, converts some pasture to crop production, and converts some forest to crop production. The model also contains a price yield elasticity, such that when the model is shocked for increased corn ethanol, crop prices increase, and yields also increase somewhat on all cropland. Thus, increased production is met through (1) cropland expansion into non-cropland (which creates land use change emissions), and (2) yield increases on existing cropland.

There are other ways in which crop production increases in addition to land expansion and yield increases. A 2013 study by Roy and Foley shows there are three other ways crop production increases: (1) using the existing standing cropland area more frequently by multiple cropping, (2) leaving less land fallow, and (3) having fewer crop failures.[14] None of these 3 ways involves a land use change, or land use change emissions. Furthermore, GTAP does not include these 3 factors: GTAP does not account for double cropping, has no fallow land inventory, and cannot model reduced crop failures. Roy and Foley point out that the influence in these 3 factors on crop production can be estimated by comparing trends in total harvested area to total cropland.

> The growth in annually harvested cropland and standing cropland has been changing in recent decades. Analyzing the 177 crops traced by FAO since 1961 shows that the amount of annually harvested land has increased much faster than the reported total standing cropland on the globe. While standing cropland has increased at the rate of 3.5 mha/year, the annually harvested land increased at a much faster rate of 5.5 mha/yr.

The difference in the above growth rates – 2.0 mha/year – is due to the 3 factors mentioned earlier, which have no land use emissions impact. The authors also examine the potential for the increase in harvested area to continue to increase faster than standing cropland in the future, and find that these trends should continue.

It is difficult to incorporate these factors into the current GTAP model, because these factors require a dynamic GTAP model, and the current model is a static model.[15] However, the analysis of these trends can be used to inform the ranges of input elasticities for the current static GTAP model used by ARB, particularly the price-yield elasticity. Increasing the price yield elasticity in GTAP increases crop production without a land use impact. Thus, the Ray/Foley study argues for a relatively high price-yield elasticity range. ARB, however, has selected a very low price yield elasticity range. This is discussed in more detail in the next section.

Review of CARB's GTAP Modeling

Price-Yield Elasticity Range

GTAP includes a price-yield elasticity of 0.25 as a default. This level is in part based on extensive research by the GTAP modeling community. [16] The Expert Working Group also recommended this value. The EWG also recommended higher values for regions with significant double cropping, since GTAP does not explicitly include double cropping. GTAP researchers have also pointed out GTAP is a medium-term

---

[14] Ray, D.K., and Foley, J.A., *Increasing global harvest frequency: recent trends and future directions,* Environmental Research Letters, (2013), 044041, IOP Publishing.
[15] Purdue is continuing to develop a dynamic GTAP model for these and other reasons.
[16] Keeney and Hertel, "Yield Response to Prices: Implications for Policy Modeling", Working Paper #08-13, August 2008, Department of Agricultural Economics, Purdue University.

model, with projections being applicable in the 5-10 year timeframe. CARB appears to concur with this timeframe for GTAP, because CARB describes the model as a "Current" model, meaning, that its estimates are applicable to the 2013/2014 timeframe, even though its primary data is for 2004.[17]

CARB, however, performed sensitivity analyses using price-yield elasticity values from 0.05-0.30 (20%-120% of the default value). CARB's selection of the lower end of the range came from a variety of price-yield studies that were very short term (1-2 years) in nature, and were clearly not appropriate for the GTAP timeframe. All studies on data less than about 2 years should not even be considered in establishing the range of this parameter to use in modeling. [18] Furthermore, CARB did not consider the analysis by Ray and Foley in determining the range of price-yield values to use.

CARB performed sensitivity analyses on several other parameters. Most of these values were in the range of 80%-120% of the GTAP default level, for example, CARB performed sensitivity modeling of the ETA parameter at the baseline (default), 80% of the baseline, and 120% of the baseline. We support performing sensitivity modeling at different price-yield levels, however, the range should be at least 80%-120% of the Purdue baseline value of 0.25, or 0.20 to 0.30. However even this range is not nearly high enough to properly reflect the increase in crop production that has occurred without land use changes reflected by Ray and Foley analysis referenced earlier.

ETL1 and ETL2 Values

CARB updated the land transformation elasticities (ETL1 and ETL2) in GTAP prior to estimating land use changes. ETL1 governs the transformations between forest, crops, and pasture, and ETL2 governs the transformations between various crops. CARB appears to have used some, but not all, ETL1 and ETL2 values from a 2013 Applied Science paper by Taheripour and Tyner. [19] In the Applied Sciences paper, Taheripour and Tyner indicate

> We tune the regional land transformation elasticities based on actual historical observations on changes in land cover and distribution of cropland among alternative crops during the past two decades. To accomplish this task we use published data on cropland use around the world by the Food and Agriculture Organization (FAO) of the United Nations over the period 1990-2010.

---

[17] See page 57 of the CARB March 11 Workshop Briefing, iluc_presentation_handouts_031014.pdf.

[18] "Discussion of the Yield Price Elasticity in GTAP", Taheripour and Tyner, Memo to ARB following March 11 workshop

[19] Taheripour and Tyner, "Biofuels and Land Use Change: Applying Recent Evidence to Model Estimates", Applied Sciences, 2013, 3, 14-38.

The differences in ETL1 and ETL2 values between the Applied Sciences paper and CARB are shown in Table 1 below.

Table 1. Differences in ETL1 and ETL2 Values Between CARB and Purdue

Region	Purdue – Applied Sciences 2013		CARB	
	ETL1	ETL2	ETL1	ETL2
Brazil	-0.30	-0.50	-0.20	-0.75
S_O_Amer	-0.30	-0.25	-0.10	-0.50
R_S_Asia	-0.10	-0.25	-0.10	-0.75
Russia	-0.20	-0.75	-0.02	-0.75
S_S_Afr	-0.30	-0.50	-0.30	-0.25

It is not clear why CARB chose different ETL1 and ETL2 values than Purdue, and what analysis or data CARB based these values on. An explanation of this should be provided for review, or CARB should use the ETL1 and ETL2 values that were developed by Taheripour and Tyner.

Model Nesting Structure

The Applied Science paper referenced above also included another major improvement in GTAP. According to the paper

> The GTAP-BIO model puts three types of land cover items (forest, pasture, and cropland) into one nest an implicitly assumes that the economic costs of converting one hectare of forest to cropland is similar to the economic cost of converting one hectare of pasture land to cropland and vice versa. This set up another key deficiency of the GTAP-BIO model. Including cropland, forest, and pastureland in the same nest could cause systematic bias in land conversion processes among land cover types due to biofuel production. In general this is not the case and often the opportunity costs of converting forest to cropland is higher than the economic cost of converting pastureland to cropland.

The Expert Working group studying elasticity parameters in GTAP identified this nesting structure as a key deficiency in the model and recommended using a revised nesting structure.

Taheripour and Tyner altered the land cover component of the land supply tree to have forest and pasture land in two different nests. Then they re-evaluated global land use impacts due to the USA ethanol program using the improved model tuned with actual observations. They showed that, compared to the old model

> The new model projects: (1) less expansion in global cropland, (2) lower share for the USA economy in global cropland expansion, (3) and lower forest share in global cropland expansion.

CARB did not include the model nesting structure changes implemented by Taheripour and Tyner, and recommended by the Expert Working Group, even though this revised model was available to CARB in early 2013. CARB should include this critical change in the GTAP model.

Additional Cropland/Pasture Areas in Canada and EU27

GTAP has been updated to include cropland/pasture in the US and Brazil (CARB used the model with these additions). Other regions of the world, such as Canada and the EU27 (and probably many other regions of the world) also have a significant amount of cropland/pasture and idle land. These land areas should be added to GTAP.

Conservation Resource Program Impacts

The GTAP model includes the ability to include CRP land in the land inventory for the US. There has been a significant amount of land converted to production from CRP land in the last seven years. Table 2 shows data from the Conservation Resource Program. [20] These data show over 10 million acres of CRP land have gone back into production. These are not forest acres that have gone into production. Over the period from 2007-2011, CRP acreage in wetlands and buffers increased. Clearly, GTAP should be run to access CRP land in the US prior to converting forests or even cropland/pasture.

[20] "Annual Summary And Enrollment Statistics", FY2011 for 2007-2011, and December 30 Reports for 2012 and 2013, http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=rns-css.

Table 2. CRP Land Enrolled	
Year	Area (million acres)
2007	36.8
2008	34.6
2009	33.8
2010	31.3
2011	31.1
2012	27.1
2013	25.6

AEZ-EF Model

Use of Carbon Data on Accessible and Inaccessible Forests to Determine Emissions from Forest Conversion

The AEZ-EF report indicates

> The carbon data used in AEZ-EF have been aggregated to GTAP-BIO boundaries, but they include both accessible and inaccessible forests, as well as grasslands other than those used for livestock grazing, and thus represent broader resources than those represented in GTAP-BIO.

It is not clear why CARB is including inaccessible forests in developing forest carbon stocks. If forests are inaccessible, then it is highly unlikely they would be converted to pasture or cropland. CARB should instead develop forest carbon from accessible or commercial forests. Detailed carbon data on public, private, and other forests is utilized by EPA in estimating its annual GHG inventories.[21] The carbon in private forests (most likely of forests to be converted to pasture/cropland) is much lower than public or other forests.

Wood Used to Produce Energy

In the new AEZ-EF model, for forest converted to cropland or pasture, CARB is now accounting for carbon stored in hardwood products (HWP). The storage rates are different for different regions, and are based on a 2012 study by Earles, Yeh, and Skog. The HWP fraction ranges between 2-36%.

In addition to accounting for carbon stored in HWP, CARB should also account for wood mass that is used for fuel during forest clearing. Wood that is burned to

[21] USDA Forest Service (2010a), Forest Inventory and Analysis National Program:User Information. U.S. Department of Agriculture Forest Service. Washington, DC. Available online at http://fia.fs.fed.us/tools-data/docs/default.asp.

produce energy (for a sawmill, for example) is replacing fossil-fueled energy, and is renewable. CARB does not count CO2 emissions from facilities that use waste wood to produce energy for fuel production (CARB does, however, count non-CO2 GHG emissions, which is appropriate). Heath et al estimate that 35% of carbon from forest clearing is used for energy.[22] In the US, Canada, and the EU27, CARB should not count the CO2 from wood used to produce energy.

CCLUB Model

CARB should consider using the (Carbon Calculator for Land Use Change from Biofuels Production (CCLUB) model for estimating emissions.[23] Like AEZ-EF, the model was designed to be integrated with GTAP. It has several advantages over AEZ-EF. First, instead of using the Harmonized World Database (HWD) for soil, it uses the CENTURY model, which contains much more specific information on soil carbon for the US than the HWD, on a county-by-county basis. Second, it uses county-by-county carbon data from forest ecosystems for the US from the Carbon Online Estimator (COLE) database, developed by Van Deusen and Heath in 2010 and 2013. [24,25] Third, it allows the user to input HWP fractions, and fourth, it does not count CO2 from the forest wood used to produce energy. For areas outside of the US, it utilizes Winrock emissions.

CARB has conducted uncertainty analysis of its land use estimates using only AEZ-EF and GTAP. Using the CCLUB model with GTAP to estimate land use change emissions would also provide more information on the uncertainty of CARB's estimates.

---

[22] L. Heath, R. Birdsey, C. Row, and A. Plantinga. "1996 carbon pools and flux in U.S. forest products", Forest Ecosystems, Forest Management, and the Global Carbon Cycle, M. Apps and D. Price, eds. NATO ASI Series I:Global Environment Changes, Volume 40, Springer-Verlag, ppg 271-278.
[23] Dunn, J., Mueller, S, Kwon, H.Y., Wander, M., Wang, M., "Carbon Calculator for Land Use Change from Biofuels Production (CCLUB)", Argonne National Laboratory, ANL/ESD/13-8, September 2013.
[24] Van Duesen, P., and Heath, L., 2010. Weighted Analysis Methods for Mapped Plot Forest Inventory Data: Tables, regressions, maps and graphs. Forest Ecol. Manage. 260:1607-1612.
[25] Van Duesen, P. and Heath, L. 2013. COLE web applications suite. NCASI and USDA Forest Service, Northern Research Station. Available at http://www.ncasi2.org/COLE/

Updated LUC Modeling

AIR downloaded ARB's GTAP model and the AEZ-EF model to determine the impacts of some of our suggestions. ARB did not supply example run results for any particular biofuel shock. ARB ran the models under 1440 different input conditions, for 5 different biofuel shocks, and determined the average emissions for each of the 1440 runs (a total of 7200 runs). The results are shown in Table 3.

Table 3. ARB Land Use Results, March 11 Workshop	
Biofuel	LUC Emissions (gCO2e/MJ)
Corn Ethanol	23.2
Sugarcane Ethanol	26.5
Soy Biodiesel	30.2
Canola Biodiesel	41.6
Sorghum Ethanol	17.5

In this analysis we test the impact of three factors that should be changed in the ARB modeling:

- ARB's ETL1 and ETL2 values
- Model Nesting Structure
- Price-Yield Range

It is clearly impractical for us to run the model 1440 times to test the impact of these 3 items. However, it is possible to test the impact with a representative model run. To create the representative model run, we first estimated the average of the ARB inputs. Next, we ran the model with a corn ethanol shock to determine the LUC emissions. Finally, we changed the price yield elasticity, until the model run gave the same answer as corn ethanol in Table 3. The average model inputs are shown in Table 4.

Table 4. Average ARB GTAP Inputs	
Input Parameter	Average Value
Price Yield (Ydel)	0.175
PAEL, US	0.3250
PAEL, Brazil	0.1875
ETA	ARB Baseline
ETL1, ETL2	ARB Baseline

When we ran the case in Table 4, we obtained corn ethanol emissions of 21.66 gCO2e/MJ. We then reduced the price yield elasticity from 0.175 to 0.1507, and obtained emissions of 23.22 gCO2e/MJ, which is the same as ARB's corn ethanol estimate. This is our single run that generally represents CARB's 1440 cases.

The impact of the 3 changes on LUC emissions for the corn ethanol shock are shown in Table 5.

Table 5. Impacts of Changes in GTAP Modeling	
Scenario	LUC Emissions (gCO2e/MJ)
AIR "Representative" Case	23.22
Change ETL1 and ETL2 parameters to Purdue "tuned" values	21.20
Implement Purdue GTAP Nesting Structure	19.00
Use Purdue Default Price-Yield Range	14.63
Include CRP Land Conversions	13.75

Table 5 shows likely emissions of 13.75 g CO2e/MJ instead of 23.22 gCO2e/MJ if these changes are implemented and the various runs are repeated. The emissions would be even lower if the model were modified to more properly reflect (1) the Ray and Foley analysis that a major part of crop production has increased without a land use change, and (2) the ARB analysis properly accounted for wood from forest that is used for fuel and replaces fossil fuel during forest clearing.

2.0 Fuel Pathways and Producer Facility Registration

Growth Energy supports the streamlining of the application process for biofuel production facilities, however, Growth Energy does not support limiting the pathways a facility can apply for, nor does Growth Energy support implementation of CI "bins" that facilities must use when registering the facilities. Both of these changes would severely limit continued innovation in biofuel facilities.

At the workshop, CARB envisioned bins of either 5, 7, or 9 CI values, with all facilities falling in a bin range getting the same, midpoint value of the bin. For a 7 CI bin case, for example, facilities falling in a bin from 61-67 would all be assigned a value of 64, whether their CI is 61.1 or 66.9. Furthermore, a facility with an actual CI of 65 (assigned value of 64) would not be able to obtain a lower CI value unless it reduced its actual CI to the upper part of the next bin range, or 60.9 (a difference of 4.1 CI). A facility at 61.1, however, with an assigned value of 64 would be able to get into the next lowest bin by reducing its CI to the same value of 60.9, a difference of only 0.2 CI. Clearly, if we are understanding CARB's bin approach correctly, it appears to have significant problems, no matter how the bins are designed.

A second major concern we have with the bin approach is that it is not at all consistent with what ARB is proposing for refineries producing gasoline and diesel. CARB's GHG Emission Reductions for Refineries proposal indicates that CARB is willing to provide credit under the LCFS regulations to refineries, with no minimum CI reduction required. In other words, a refinery that has a project to reduce its CI by 0.1 CI would receive consideration. But under the binning approach for biorefineries above, there is a much higher minimum threshold for consideration of a lower bin. Thus, gasoline/diesel refineries receive special treatment that biofuel facilities do not.